The Easy Way to Energy Harvesting Wireless Products

Energy harvesting enables electronic control systems to operate independently of external power by harvesting energy from motion, light, or temperature differences in their surroundings. EnOcean's complete platform of hardware, software and ultra-low power radio enables battery-less, wireless automation solutions that operate maintenance-free for different fields of application. Along with several tools, this platform allows manufacturers to easily integrate this technology into a reliable, aesthetically pleasing product design.

Technology for maintenance-free solutions

Long established in the commercial building automation and smart home market, energy harvesting wireless technology is widely used by manufacturers for solutions and connected applications in the fields of consumer technology/Internet of Things (IoT) and machine-to-machine (M2M) applications. The reason is simple: energy harvesting technology is an attractive option to utilize devices that can communicate without wires or batteries. This brings high flexibility to device placement as a device can be placed wherever needed while freeing the user of the burdensome task of changing batteries. By avoiding battery waste, energy harvesting brings the maintenance-free aspect to wireless devices.

Ready-made modules

With energy harvesting wireless technology, manufacturers have a solid foundation upon which to design devices that fulfill all requirements of flexible, reliable and sustainable solutions. For a smooth integration, the energy harvesting wireless technology platform is composed of optimally matched components including energy harvesters, ultra-low power electronics, reliable wireless communications and energy management. This simplifies the design of new products as the manufacturer does not need to have expertise in radio or energy harvesting technology. The switch modules PTM 210 & PTM 215 are a good example of this. They combine the field-proven electro-mechanical energy harvester, the ECO 200, and an ultra-low power radio module in a perfect housing. This form factor fits in any standardized switch design worldwide so that the manufacturer can take the complete module and integrate it into a switch shell. The result is a ready-made battery-less device that generates energy with the tap of a finger. For effortless product integration, EnOcean offers a wide range of miniaturized energy converters, wireless modules, tools and software.

EnOcean protects its innovative developments through worldwide patents covering basic concepts, components or applications.

Kinetic Energy

The electro-mechanical ECO 200 energy harvester, combined with a transmitter module, enables an entire system for battery-less, wireless switch integration by converting mechanical energy into immediately available electrical energy. With an energy output of 120 µWs, it is possible to transmit three radio telegrams per actuation. Manufacturers can use the ready-made switch module PTM 21x or combine the ECO 200 with the smaller PTM 535 module, which lays the foundation for industrial switches or other applications where smaller form factors are required.

Design-in Specifics

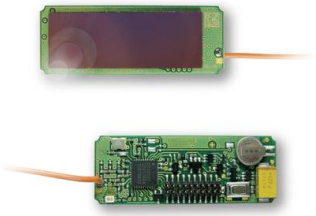
To ensure that the energy converter can consistently meet its specified characteristics, such as a long lifecycle and reliable energy output, manufacturers who combine the ECO 200 with the PTM 535 should take some design rules into account when installing it in an application. The converter should be firmly connected via the interfaces indicated (free of play) and the minimum actuation stroke of 0.7 inches on the leaf spring should be strictly observed – these are critical factors for reliable operation. The maximum actuation stroke of 0.13 inches is also important for ensuring that no premature damage occurs to the converter. When actuating the leaf spring, product designers need to ensure that the complete travel distance affects only the leaf spring and that the energy converter remains in a fixed position.

Solar Energy

Many sensor applications are powered by miniaturized solar cells. For this, EnOcean offers a range of modules with pre-installed solar cells, such as:

- STM 33x temperature sensor
- STM 33x magnet contact sensor
- STM 350 temperatur & humidity sensor
- STM 550 multisensor (acceleration, temperature, humidity, light and magnet with NFC configuration)

The solar-powered STM 33x (868 / 902 / 928 MHz) sensor, for example, can measure temperature in a room or on machinery. This module is characterized by its extremely low-power consumption and high reliability. If a measured value is transmitted every 15 minutes, for instance, 3.6 hours of charging in daytime of at least 200 Lux are adequate for continuous operation. With its energy storage mechanism fully charged, the module is functional for several days in complete darkness.



Thermal Energy

Using the ECT 310 DC/DC converter combined with a Peltier element, manufacturers can also utilize thermo-electric powered applications. Temperature differences offer the ability to harvest a great deal of energy. For example, the warming of a drop of water by one degree Celsius (°C) requires the same amount of energy needed to send about 10,000 EnOcean wireless telegrams. That is enough to operate not just a wireless sensor, but even wireless actuators such as heating valve actuators. The ECT 310 DC/DC oscillator starts to operate at a minimum of 10 mV as the input voltage. On 20 mV or more (i.e. about 2 °C) a useful output voltage of more than 3 V is generated. To enable this high converter efficiency of 30% at 20mV, the output voltage is only roughly regulated to less than 5V over the entire input voltage range up to 500 mV. This is similar to the unregulated supply voltage from solar cells. As EnOcean wireless modules are optimized for a wide input voltage range the ECT310 is a perfect match for energy harvesting applications that take advantage of temperature differentials.

Comprehensive Module Portfolio

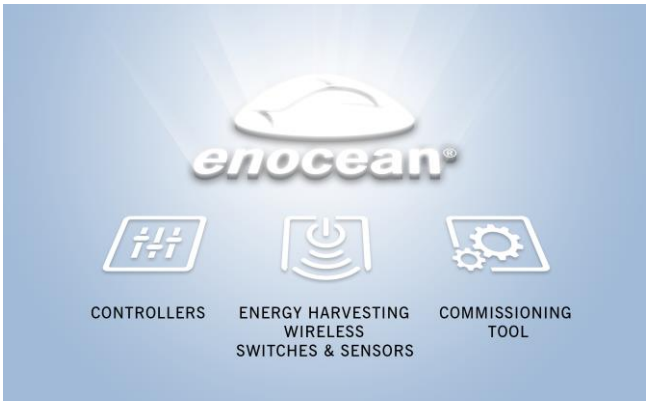
The sensor modules go hand in hand with powerful transceiver modules for efficient RF repeaters, transceivers or gateways as well as programmable system components. The non-programmable, pre-configured TCM 310, TCM 410J and TCM 515 enable the utilization of gateways for EnOcean radio systems by providing a bidirectional radio interface at one end and a bidirectional serial interface at the other. Radio messages are sent transparently through the serial interface in both directions from and to an externally connected host processor or host PC. In addition, control commands can be sent from the host, for example, to configure the repeater functionality or to manage the Smart Acknowledge functions. The TCM 310 can act as postmaster for up to 15 bidirectional sensors using Smart Acknowledge technology, a bidirectional protocol that manages the communication between a controller and EnOcean-based self-powered devices.

TCM transceiver gateway modules are also available and integrated in the USB 300, USB 400J, and USB 500U gateway, which connects PCs, consumer devices, DSL boxes and other USB master devices to the world of EnOcean-based wireless products. They provide bidirectional EnOcean radio and bidirectional serial interface via USB. Radio messages are sent and received via an externally connected USB host.

The transceiver modules TCM 300 and TCM 320 can both be programmed to contain the functionalities of RF repeaters and transceivers. The Gateway Controller is the universal transparent gateway firmware, which can be used to communicate with an EnOcean network. The firmware includes Smart Acknowledge and Remote Management and is ideally suited for applications where a second micro-controller is used.

White Label Finished Products

EnOcean's wide range of white label finished products of switches, sensors and relay receivers enables OEMs to focus on developing their core products internally while quickly and economically bringing EnOcean-based product portfolios to the market. The battery-less product suite for OEMs includes occupancy sensors, a window contact, light switches, and a key card switch as well as HVAC and electrical load control modules based on EnOcean's energy harvesting wireless technology.



Additionally, EnOcean offers OEMs a comprehensive LED control system tailored to meet the needs of the North American market. This system is based upon innovative self-powered sensors and switches combined with LED fixture controllers and a commissioning tool to simplify installation and setup. The LED controller family includes the transceiver module (TCM 330U) for integration into drivers and modules as well as LED fixture/zone controllers with relay and 0-10V output (LEDR), and without relay (LEDD). The list is completed by white label self-powered wireless switches, occupancy and light level sensors as well as Navigan, an easy-to-use

commissioning tool to link devices and setup parameters over the air from a graphical user interface (GUI).

Frequency for worldwide use

There are data sheets and user manuals available for all EnOcean products, which can be found at www.enocean.com/products.

The products are offered in the frequencies

- 868 MHz (Europe and other countries according to R&TT specification),
- 902 MHz (North America according to FCC/IC-specification; U-series),
- 928 MHz (Japan according to ARIB specification; J-series) and

for worldwide use based on the ISO/IEC 14543-3-1X international standard.

On top of this standard, which covers the physical, data link and network layers of the OSI (Open Systems Interconnection), the EnOcean Alliance defines the EnOcean Equipment Profiles (EEP). These standardized application profiles ensure the interoperability of EnOcean-based products from different vendors. Manufacturers who develop EnOcean-based products and solutions join the EnOcean Alliance to get access to the EEPs and the technical specifications of the standardized EnOcean ecosystem and are also included in the organization's worldwide marketing activities.

For specific applications outside of building automation and smart home, EnOcean also enables the 2.4 GHz frequency band (IEEE 802.15.4) to be powered by energy harvesting.

Advanced Security Mechanisms

All EnOcean modules have a unique 32-bit identification number (ID), which cannot be changed or copied and therefore protects against duplication. This authentication method already offers field-proven secure and reliable communication in building automation. For applications requesting additional data security, a security mode protects battery-less wireless communication with enhanced security measures. These include a maximum 24-bit rolling code (RC) incremented with each telegram, which is used to calculate a maximum 32-bit cypher-based message authentication code (CMAC). The CMAC uses the AES 128 encryption algorithm. Another mechanism is the encryption of data packets by the transmitter. The data is encrypted using the AES algorithm with a 128-bit key.

The EnOcean standard 868 MHz sensor modules integrate these state-of-the-art data encryption mechanisms to meet the requirements of specific applications such as monitoring or alert sensor systems. These enhanced security mechanisms can optionally be activated to prevent different types of attacks, including replay and eavesdropping attacks or forging of messages. Shipped in standard mode, the encrypted data transmission can be activated by simply pressing the learn button for ten seconds. If needed, the security mode can be deactivated by pressing and holding the learn button again. Also a receiver that decodes encrypted telegrams can still process standard telegrams enabling OEMs to effortlessly include enhanced data security in their existing EnOcean-based portfolio.

Development Platform

To support OEMs in successful product development for varied energy harvesting wireless applications, EnOcean has set up a cost-effective and customized development platform for fast integration of battery-less technology into building and industry automation, smart home as well as machine-to-machine or transportation systems.

At the core of EnOcean's modular developer offer is the EDK 350 developer kit covering the entire product range, from energy harvesting and wireless modules to ready-made product solutions. The developer kit's central element is the EOP 350 universal programmer board. Developers can use it to configure or program EnOcean radio modules within their production environment.

Development Tools

Well-established development tools for download complement the hardware portfolio to enable simplified product design.

The **DolphinAPI** is a software interface for programming TCM 3xx/STM 3xx modules. The API (Application Programming Interface) enables manufacturers to quickly develop software for dedicated applications.

The **DolphinStudio** suite provides the graphical user interface to configure all necessary items using the API. It can also be used separately for simple configurations and flash programming of Dolphin modules.

With **DolphinView**, combined with TCM 3xy/TCM 410J, developers can get detailed information on sub-telegram timing and signal strength, for example. The telegrams' content can be analyzed online and logged with a time stamp. DolphinView supports remote management features like ping, query and remote learn.

EnOcean Middleware

With EnOcean Link, EnOcean offers OEMs also a middleware for energy harvesting wireless technology. Using the licensed software, OEMs can integrate EnOcean technology easier and faster into a wide range of applications and systems, such as those in smart homes. The software provides a universal interface for wireless communication and automatically interprets information from EnOcean telegrams. As a result, sensor data such as humidity or temperature is automatically arranged so that different devices, servers and even cloud services can process it immediately.

The middleware automatically takes into account all specifications of the EnOcean protocol stack, all frequencies available and the EEP of the EnOcean Alliance as well as encryption mechanisms. Since the software interprets all data, it also ensures the interoperability of equipment from different manufacturers. Instead of developing their own software for a particular application in order to interpret the communication protocol of the energy harvesting wireless technology, OEMs can use the finished middleware for this purpose immediately. EnOcean Link is suitable for receiver and gateway solutions as well as for any application that integrates or further processes the energy harvesting wireless radio

Comprehensive Support

EnOcean offers several support tools for manufacturers and product developers:

- How-to-videos demonstrate basic product integration specifics for the EnOcean technology. These include, for example, the use of the starter and developer kit, the programming of a transceiver module or the configuration of a sensor module.
- In System Specification, developers find a range of documents, which technically explain the EnOcean serial protocol 3 (ESP 3), EnOcean Radio Protocol (ERP), the EEP or Remote Commissioning of EnOcean networks, for example.
- Application notes for energy harvesting wireless sensor solutions add to the comprehensive technical documents. They cover system design, high frequency design, energy harvesting, sensors, actuators/relay receivers, software and tools.
- Beside the online tools, manufacturers can contact the company's worldwide application engineering team for personal support at support@enocean.com.

Endless Energy

With battery-less operation, a device achieves a highly attractive unique selling proposition to gain a strong market position. The technology, track-proven and well-established, is a reliable alternative to batteries and wires, bringing the eco-friendly, maintenance-free character to a device.

The platform approach of EnOcean's energy harvesting wireless technology keeps the integration hurdles for manufacturers extremely low. They have access to all needed components, which are already optimally matched to each other. This makes it easy to replace battery or wire power with energy harvesting.